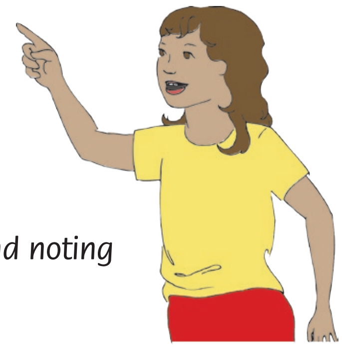
Exploration 6: Long and Short Rotor Blades



Students investigate how a rotor blade's length affects the amount of lift it generates.

Main Concept

People can often learn about things by doing something to the things and noting what happens.

Goal

Students will design and construct simple models and use them to conduct a scientific investigation into how the length of a rotor blade affects the amount of lift it generates.

Objectives and Standards

Objectives	Standards
1. Students will design and construct simple models that use long rotor blades and short rotor blades for flight. 2. Students will conduct an investigation in rotorcraft flight using the models they construct. 3. Students will differentiate between the flight of a model using a long rotor blade and the flight of a model using a short rotor blade. 4. Students will measure the length of rotor blades with a ruler. 5. Students will develop the ability to do scientific inquiry. 6. Students will develop an understanding of scientific inquiry. 7. Students will work collaboratively with a team and share their findings.	**Partially Meets:** 2061: 1B (K-2) #1 2061: 1B (3-5) #1 2061: 1C (K-2) #2 NCTM: Measurement, (K-2) #7 NSES: A (K-4) #1, #2 **Addresses**: 2061: 4F (3-5) #1

Prerequisite Concepts

- *A model of a rotorcraft can be used to test how a rotorcraft flies.*
- *The rotor blades on a rotorcraft spin and provide the force to lift the rotorcraft.*
- *Changes in speed or direction of motion are caused by forces. The greater the force is, the greater the change in motion will be.*

Links to Resources that Address Prerequisite Concepts

Robin Whirlybird Exploration #1: What is a Model?
Robin Whirlybird Exploration #2: How Do Rotorcraft Fly?
Robin Whirlybird Exploration #3: How Do Rotors Create Lift?
Robin Whirlybird Exploration #4: Rotorcraft Flight and Lift
Robin Whirlybird Exploration #5: Rotor Blade Shape and Flight

Robin Whirlybird
http://rotored.arc.nasa.gov/story/robin18.html
http://rotored.arc.nasa.gov/story/robin3.html
Click on button "Rotorcraft Activities"

New Concepts

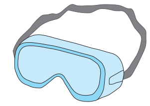
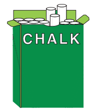
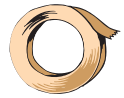
- *Scientific inquiry involves learning about things by doing something to the things and noting what happens.*

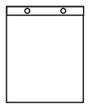
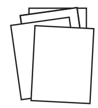
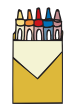
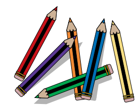
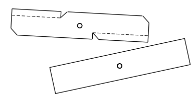
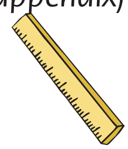
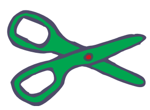
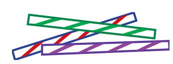
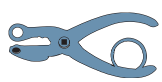
- *Scientific investigations may take many different forms, including observing what things are like, what is happening somewhere and doing experiments.*

Schedule

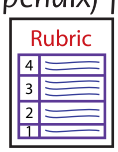
Allow 2-3 sessions of 20-40 minutes.

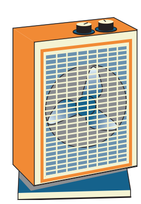
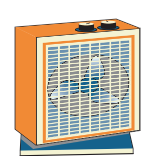
Materials

- Protective eyewear for each student, available from most school science supply stores and catalogs 
- Chalk or tape  

- Chart paper 
- Drawing paper and crayons or coloring pencils   
- At least one template for long and short rotor blades (See this exploration's appendix) for each team/pair 
- Rulers 1 per team/pair 
- Cardstock for constructing rotor blades 
- Scissors 1 per team/pair 
- Sturdy plastic drinking straws (approximately 3 straws per team/pair) 
- Hole punchers 1 per team/pair 
- Cellophane tape roll 1 per team/pair 
- Stopwatches or watch/clock with second-hand 

- At least one Data Table (see this exploration's appendix) for each team/pair 

- Evaluation rubric in this exploration's appendix 

- Two house fans with blades that rotate at close to the same rate, one with longer blades than the other  

Safety Precautions

When using flying objects in a classroom, post very strict rules and review them with the students. All students MUST wear protective eyewear while any object is in flight. Clearly delineate one or more staging areas, preferably with students' input. Mark on the ground with chalk or tape, where all "test flights" will take place. Caution students to "secure the area" before beginning any "test flight."

Engage

1. Draw on students' prior knowledge of rotorcraft.
   - Question: What do rotorcraft need so they can fly?

   Rotorcraft need spinning rotor blades in order to gain lift.

2. Tell students that today they will be scientists investigating how the length of rotor blades affects the flight of rotorcraft.
   - **Question:** How do you think the flight of a rotorcraft will be affected if we change the length of the rotor blades?
   - List students' responses on chart paper. These responses are their hypotheses.
   - Ask students how they can test their guesses or hypotheses. Students may want to proceed as they did in the last exploration, and design and create rotorcraft models and test them.

3. Students will need to be engaged in the design process as a class or in teams or pairs.
   - Have each team or pair present their design to the class.
   - Follow up each short presentation with a brief discussion as to the design's viability.
   - Students can choose to put all their design ideas together into one really good idea or agree to use two of the more viable designs.

4. Use the students' designs or the template in this exploration's appendix.

5. Ask students to use the rulers to measure the length of their rotor blades.

6. Have students construct their long-bladed and short-bladed rotors from cardstock, using the template, cutting out the shapes and connecting the rotors to straws using tape.

7. Once the models are constructed proceed to the next section.

Explore

1. Ask: Using our model, how can we find out if there would be a difference in the way the model flies using a long rotor blade or a short rotor blade?

2. Invite students to discuss and explore the answer to this question.

3. Working in their student teams or with partners, have the students draw out step-by-step how they would set up a test to verify each rotor blade's flight.

4. Have students share their experiment ideas with the class.

5. After discussing each proposed experiment have students help each team make revisions in their experiment design by asking questions about "how it will work."

6. Give each team time to revise their experiments.

7. Have students share their revised experiment ideas again with the class. After discussing all the proposed experiments, decide if only one test should be developed from all the good ideas or whether each team should go ahead with their own.

8. **Question:** How can we make this a fair test?

9. Solicit ideas and direct students' focus toward holding the model the same distance from the ground each time, testing in an area without moving air, performing the test a certain number of times and making the rotor blades rotate at the same rates (as much as possible). Have the group come to consensus on these test factors.

   Note to Teacher: This will be a "fair test" if both the short and long rotor blades are made of the same materials, are the same width, are flown under the same conditions and carry the same "load" (or weight).

10. Discuss safety issues. Emphasize proper observation skills and the importance of "thinking aloud." Distribute the protective eyewear.

11. Distribute stopwatches.

12. Allow 10 minutes for open explorations. Record students' observations, actions, ideas and questions.

13. Monitor safety and proper use of materials.

Explain

1. Have students in pairs draw a picture that depicts the results of their long/short blade experiments and the model's flight.

2. Record the data in a table like the Data Table in the Appendix. The left column of the table can be used to draw the length of the blade, and the right column to list the amount of time the rotorcraft stayed aloft.

3. Have the class decide how this data could be depicted. (For example, a bar graph, line graph or pictograph.)

4. Gather students together for a discussion.

5. Reflect upon the questions the students raise based upon your own classroom observations during their exploration time.

6. Ask the group to draw a conclusion about the rotor's length and its flight performance.

   Note to Teacher: In a fair test the results should demonstrate that the long rotor blade is better at generating lift than the short rotor blade, however, it takes more effort to rotate the long rotor blade. Students may notice that it takes more effort to get the long rotor blade to fly. This does NOT mean that longer rotor blades are always better. For example, one would not need really long rotor blades for a two-seater, lightweight helicopter. However, a heavy-lifting helicopter would need longer rotor blades to generate the lift it needs while carrying a heavy load through the air.

7. Show students their hypothesis and compare the hypothesis with the conclusion. Ask students how their original hypothesis should be changed.

Extend

1. If possible, find two house fans with blades that rotate at close to the same rate and have identical fan blade shape, but one has longer fan blades. Present these two fans to the class. Before turning them on, ask the students to predict which one will generate more air movement.
   Note: The fan with longer blades will generate more air movement.

2. Ask students to explain how a fan is like the rotor blades on a rotorcraft.

Evaluate

Use the rubric in this exploration's appendix and evaluate students on the following:

1. *Rotor blade design and construction of the rotorcraft model*
   Students can also use the rotor blade design in this exploration's appendix to construct their models.

2. *Investigation*
   - *Students should carry out the investigation with a partner or a team.*
   - *They conduct a "fair test" and collect and record data.*

3. *Reaching a conclusion*
   Students reach a conclusion based on their data.

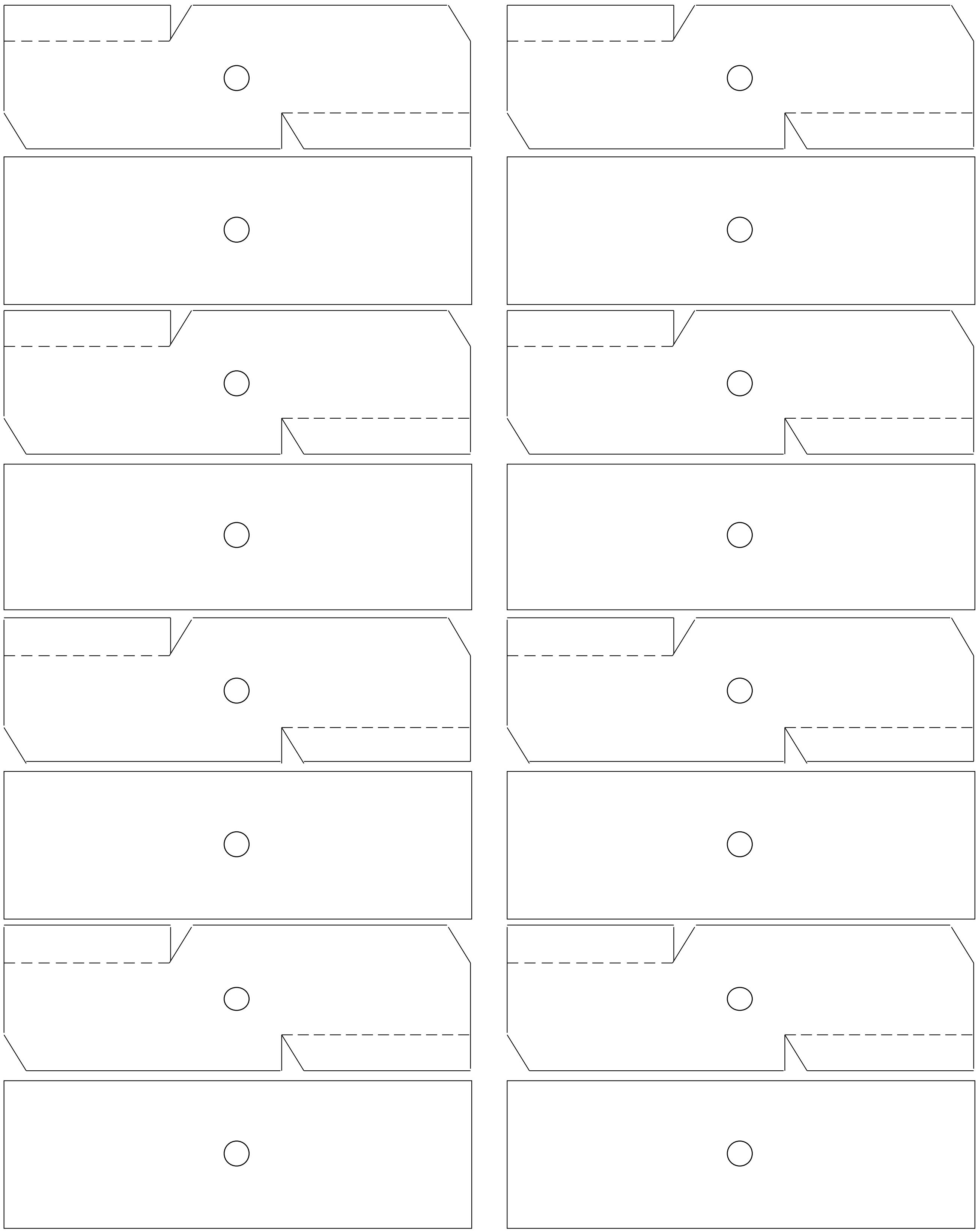
4. *Revise hypothesis*
   Students revise their hypothesis based on their data.

Further Exploration

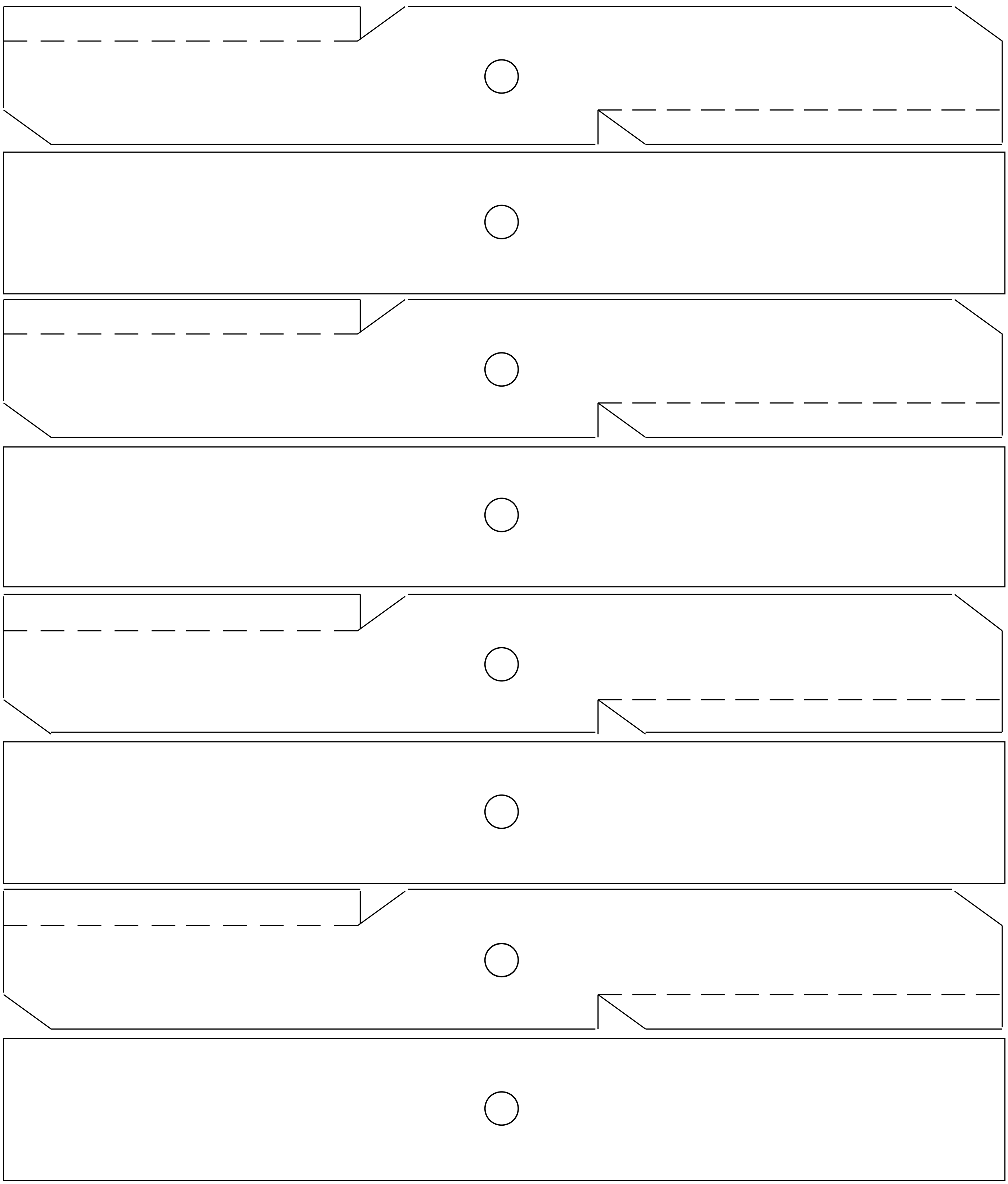
- *Students might have additional questions such as whether long rotor blades can carry more weight in flight than short rotor blades.*

- *Another exploration could arise from a question about the shape and length of the rotor blade. That is, can the shape and length of the rotor blade be adjusted so that more weight can be carried?*

Appendix: Propeller Template - Short



Appendix: Propeller Template - Long



Exploration 6: Long and Short Rotor Blades

Data Table

Team Members:

__________________________ __________________________

__________________________ __________________________

Use this table to record your observations. Draw or describe the rotor blade.

Rotor Blade Length	Observation	Time

Exploration 6:
Long and Short Rotor Blades Rubric

Students investigate how a rotor blades' length affects its ability to generate lift.

Evaluate students' work using the following rubric:

4	• *Clear rotor blade design and construction of the rotorcraft model* • *Conduct a "fair test" and collect and record data* • *Reach a conclusion based on the data* • *Revise hypothesis based on data and conclusion*
3	• *Some attempt at rotor blade design and construction of the rotorcraft model* • *Attempt to conduct a "fair test" and collect and record data* • *Attempt to reach a conclusion based on the data* • *Attempt to revise hypothesis based on data and conclusion*
2	• *Construction of the rotorcraft model without a design* • *Some attempt to conduct a "fair test" and collect and record data* • *Reach a conclusion based on some of the data* • *Attempt to revise hypothesis*
1	• *Little or no rotor blade design and construction of the rotorcraft model* • *No "fair test" conducted* • *Conclusion not based on data* • *Limited revision of hypothesis*